

# HMMWV Improvements “Monster Garage<sup>®</sup>” Program

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## 1. ABSTRACT

The overall goal of the program was to find readily accessible ways to increase payload, performance and protection. Each of these areas had been compromised over the course of time due to unanticipated threats and increased weight on the High Mobility Multipurpose Wheeled Vehicle (HMMWV), which has led to a decrease in payload and performance. The basic request from the Vice Chief of Staff of the Army was to improve underbody protection while buying back payload and automotive performance, and so program leaders set goals to:

1. Increase *protection* for the Soldiers currently using the M114 HMMWV.
2. Increase the vehicle's *performance*, which had degraded over time due primarily to the added weight of armor.
3. Buy back *payload* to pre-frag-5 (armor) kit levels.

The HMMWV “Monster Garage” program accomplished what many thought was impossible. It created a joint government/industry group of subject-matter experts (SMEs) working intensely as a team to yield quickly applicable solutions. At its peak, the team consisted of approximately 100 SMEs representing more than 20 government and industry organizations. It was led through a 10-week cycle of one-week meetings at RDECOM-TARDEC followed by a week of fact-finding, modeling and simulation excursions, including expert choice analyses. This allowed the group to develop technology enhancements for the baseline vehicle systems, the M114 up-armored HMMWV with Frag Kit 5.

The team's recommendations were first presented to senior TARDEC, RDECOM, Army Materiel Command, Program Executive Office Combat Support and Combat System Support and Assistant Secretary of the Army leadership and then to the Army Vice Chief of Staff. “We need to let Soldiers in the field know that we're back here fighting to find solutions to provide them the protection they need,” GEN Richard A. Cody said in response to the group's presentation. “This HMMWV improvements team is doing just that. They've developed innovative solutions to critical field requirements, and we are going

to pursue those solutions to ensure that our Soldiers have the protection they need.”

The payload, performance and additional reliability improvements proposed were provided to Project Manager for Light Tactical Vehicles (PM LTV) for consideration. PM LTV crosswalked the 32 suggested improvements and is implementing 12 in the Reliability Enhanced Vehicle (1151/2) with an additional 15 improvements expected in the engineering, manufacturing and development (EMD) phase, for a total of 27. Twenty-four are incorporated in the Expanded Capacity Vehicle (ECV) 2 with 5 improvements expected in the EMD phase, for a total of 29.

Following the successful presentation to the Vice Chief of Staff of the Army, RDECOM TARDEC was tasked by the Department of the Army (DA) to demonstrate that DA G8 Monster Garage threshold protection levels for underbody mine blast and underbody explosive blast/fragmentation are attainable on a lightweight tactical vehicle. Based on this guidance, TARDEC is pursuing development of the HMMWV Monster Garage double V cab for demonstration through successful ballistic tests.

## 2. INTRODUCTION

The U.S. Army and Marine Corps have thousands of M114 HMMWVs deployed in Iraq and Afghanistan. Interim replacement vehicles are already in theatre. Longer-term replacements are in development and testing. With so many legacy vehicles in operation and the fact that the HMMWV is going to be with the U.S. military for years to come, the need to get improved vehicles to the field quickly is paramount.

That is why the Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology tasked TARDEC with implementing actionable solutions to increase protection for Soldiers riding in the HMMWV, performance, which had degraded over time, and payload capabilities, which had decreased due to added equipment.

To accomplish these goals, TARDEC used an innovative “Monster Garage” approach. On Feb. 26, 2007, TARDEC's government and industry HMMWV

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Improvement Program (HIP) team initially formed. The concept behind the team was to take the existing M1114 and analyzing each of its systems, subsystems and kits with the goal of improving force protection while buying back performance and payload to pre-Frag Kit 5 levels.

### 3. TECHNICAL DESCRIPTION

The program's goal was to find readily accessible ways to increase payload capabilities, performance and protection. Each of these areas were compromised over time due to the HMMWVs' increased weight as well as unanticipated threats. The basic request was to improve underbody protection while buying back payload and automotive performance. This involved three parts:

- (1) Increase *protection* for the Soldiers currently using the M1114 HMMWV.
- (2) Increase the vehicle's *performance*, which had degraded over time due primarily to the added weight of armor.
- (3) Buy back *payload* to pre-frag-5 (armor) kit levels.

The HIP accomplished what many thought was impossible. It created a joint government/industry group of SMEs working intensely as a team to yield quickly applicable solutions by using a "Monster Garage" community approach (Fig. 1). At its peak, the team consisted of approximately 100 SMEs representing more than 20 government and industry organizations. The team used a 10-week cycle of one-week-long meetings at TARDEC followed by a week of fact-finding, modeling and simulation excursions. This allowed the group to develop technology enhancements for the baseline vehicle system, the M1114 up-armored HMMWV with Frag Kit. This nontraditional approach results in innovative solutions.

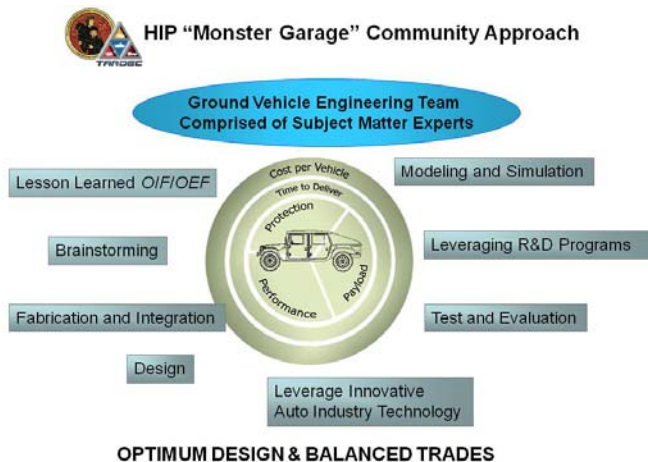


Fig. 1: Community approach process

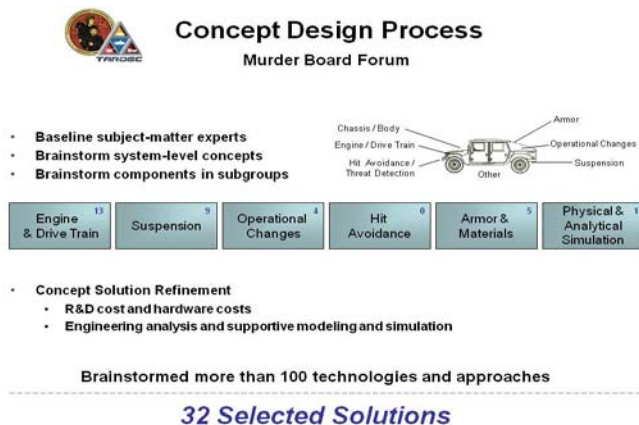


Fig. 2: Concept design process

The HIP team created a baseline by compiling the current status of the threats, vehicle characteristics, current operations in *Operation Iraqi Freedom/Operation Enduring Freedom* and existing industry and government technology. After brainstorming at the component and system levels, the team used "expert choice paired comparison" in conjunction with a "murder board" concept design process (Fig. 2) to identify possible technologies that could meet the program's goals.

More than 100 technologies and approaches were brainstormed during the HIP effort, ultimately resulting in 32 solutions (Fig. 3).



Fig. 3: Selected solutions

Several direct solutions were generated to reduce weight and increase payload capabilities including:

- Composite doors and hood
- New starter motor
- Lightweight Gunner's Protection Kit.

Solutions relating to performance and protection were designed to work together to increase the payload buyback.

Performance areas addressed during the effort included suspension and frame issues (Fig. 4).

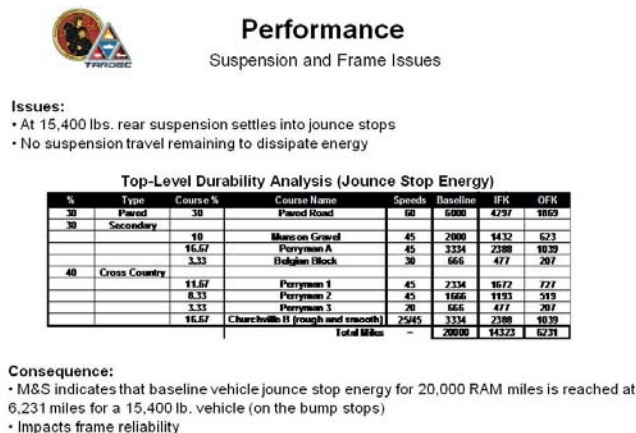


Fig. 4: Performance

For example, at 15,400 lbs., the rear suspension settles into jounce stops, and there was no suspension travel remaining to dissipate energy. Consequences include decreased frame reliability, and the baseline-vehicle jounce stop energy originally designed for 20,000 Reliability Availability Maintainability miles is now being reached at 6,231 miles for a 15,400-lb. vehicle.

Solutions to these problems included filling the frames with urethane foam or using a new 3-piece frame (Fig. 5). These solutions allowed a 20 percent reduction in peak stress and more consistent and higher strength properties.

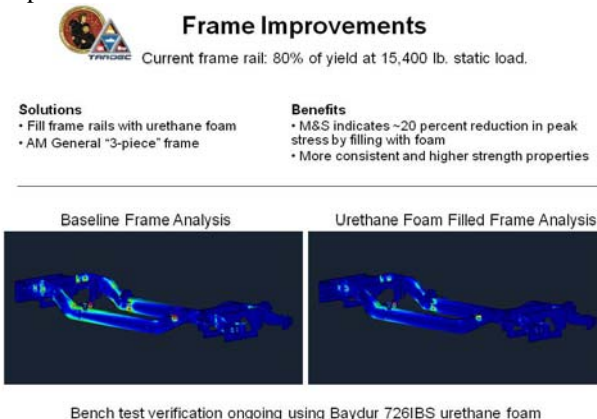


Fig. 5: Frame improvements

Additionally, when upgraded suspension and steering elements were added, there was an overall weight savings of 610 lbs. Since the initial improvement suggestions

were made, PM LTV, who oversees the HMMWV, has deduced that the benefits of improving shocks and springs includes a restoration of wheel travel, improved handling, increased durability and the potential of adjustable ride heights to use the 3-piece frame rail in production (Fig. 6).

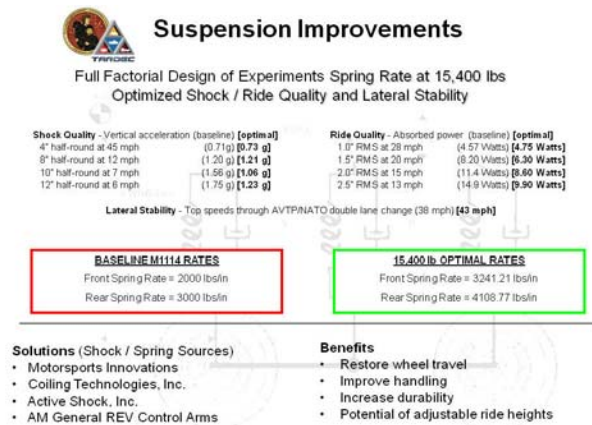
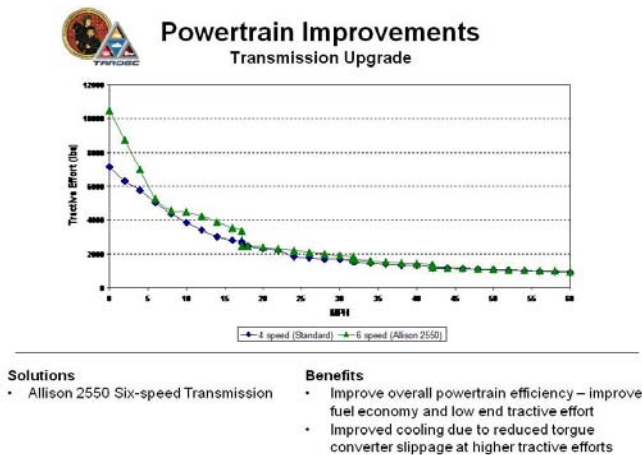


Fig. 6: Suspension improvements

There were also significant performance improvements suggested, including:

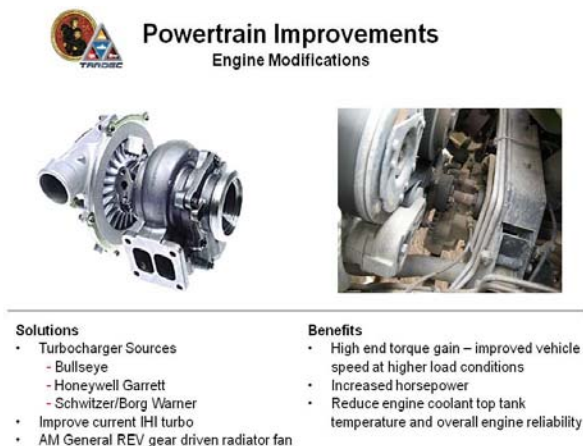
- New transmission and torque converter
- Engine turbo improvements
- New fuel filter and pump
- Optimized radiator fans
- Exhaust improvements
- Synthetic fluids
- Wheel, tire, spring, shock and ball joint upgrades
- New brake calipers, pads and intermetallic rotor coatings.

Improvements to the powertrain would be made through a transmission upgrade to the Allison 2550 6-speed transmission to improve overall powertrain efficiency, fuel economy and low-end tractive effort (Fig. 7).



**Fig. 7: Powertrain improvements – transmission upgrade**

Cooling could also be improved due to reduced torque converter slippage at higher tractive efforts. Other improvements to the powertrain included engine modifications, such as installing an enhanced turbocharger, improving the current IHI turbo and adding a gear-driven radiator fan. These solutions provide high-end torque gain with improved vehicle speed at higher load conditions, increased horsepower, reduced engine coolant top tank temperature and reduced overall engine reliability (Fig. 8).



**Fig. 8: Powertrain improvements – engine modifications**

The HIP team concluded that two major improvements would have the greatest impact for protecting Soldiers. Both a double V cab and standard cab, each produced with advanced materials, were seen to have lifesaving effects in the case of a blast or explosion fragmentation. Initial modeling and simulation indicated that the advanced material and friction stir welding

process solution would meet the threshold for the explosive fragmentation and blast requirements as depicted in the double V cab concept. Furthermore, blast simulations indicate that the double V cab remains intact. Depending on the results of a development and integration exercise, the standard cab may no longer be considered. Additionally, improved seating with energy-absorbing qualities and a 4-point restraint was found to be a vital component of mitigating the blast effects on cab occupants.

These technological advancements will work together to create an overall package of increased payload capabilities, performance and protection enhancements.

The payload, performance and additional reliability improvements proposed were provided to PM LTV for consideration, the PM LTV crosswalked the 32 suggested improvements and is implementing 12 in the Reliability Enhanced Vehicle (1151/2) with an additional 15 improvements expected in the EMD phase for a total of 27, or 84 percent. Twenty-four are incorporated in the ECV 2 with five improvements expected in the EMD phase, for a total of 29, or 91 percent. The PM is using the 3-piece frame instead of the foam-filled frame but is not yet pursuing the new cab design or gunner protection kit, pending ballistic tests and development.

Following the successful presentation to the Vice Chief of Staff of the Army, TARDEC was tasked by DA to demonstrate that DA G8 Monster Garage threshold protection levels for underbody mine blast and underbody explosive blast/fragmentation are attainable on a lightweight tactical vehicle. Based on this guidance, TARDEC is pursuing HMMWV Monster Garage “double V cab” development for demonstration through successful ballistic tests.

## 4. CONCLUSIONS

Ultimately, the team delivered a package of improvements with complimentary components that could be fully integrated with an existing, in-service platform. These improvements significantly enhance that platform’s protection, performance and payload capabilities. The team’s recommendations were first presented to senior leadership from TARDEC, PM TWV, the Program Executive Office Combat Support and Combat Service Support and, subsequently, to the Army Chief of Staff in early May 2007.

The “Monster Garage” effort is an important achievement for the Army for a variety of reasons, including increased survivability and better performance and payload capabilities. This effort has also laid the

groundwork for future improvements to the HMMWV and other ground vehicles through technological advancements and innovations.

The HIP has been awarded with both the U.S. Army Research and Development Achievement Award and a collaboration awards during the fiscal year of 2008.